

**SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT**

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**Preliminary Draft Staff Report for**

**PROPOSED AMENDED RULE 1162 - POLYESTER RESIN OPERATIONS**

March 2005

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## **EXECUTIVE SUMMARY**

The proposed amendments for South Coast Air Quality Management District (AQMD) Rule 1162 - Polyester Resin Operation will delete the requirement for the nonatomizing spray application for gel coats and improve rule language clarity.

On July 1, 2003, Rule 1162 required composite fabricators to operate their nonatomizing spray application equipment at conditions that result in volatile organic compound (VOC) emissions at or below the values stated in the Unified Emission Factors (UEF) table attached to the rule. The industry had documented to the AQMD that they were experiencing difficulty in implementing the requirement to apply gel coat with nonatomizing spray application equipment. Rule 1162 was last amended by the AQMD Governing Board on July 9, 2004, to extend the effective date of gel coat nonatomizing spray application requirement from July 1, 2004, to July 1, 2005. The extension also allowed implementation of the March 2004, AQMD Governing Board directing to staff to conduct testing of equipment used in the nonatomizing spray application of gel coats (Rule 1132 Amendment Resolutions 2004) for the purpose of verifying the effectiveness of the nonatomizing application technique and selecting a more appropriate definition for it.

In an effort to implement the Governing Board's direction for testing, staff, in cooperation with American Composite Manufacturers Association (ACMA), spray equipment manufacturers, gel coat manufacturers, and major composite fabricators developed the AQMD Gel Coat Testing Program Protocol. The objective of the testing program was to develop a more appropriate and enforceable definition for the nonatomizing spray application technique of gel coats. Testing included VOC emission and surface quality measurements (porosity, gloss, orange peel and water resistance tests) of gel coat sprayed materials. The four (4) major spray equipment manufacturers participated in the testing program, which was conducted from August through October 2004. Volatile Organic Compound (VOC) emissions were measured by AQMD staff. Surface quality analyses were conducted by staff of California Polytechnic State University, San Luis Obispo.

The Gel Coat Testing Program verified that the pressure at the tip of the spray gun is a critical parameter affecting emission rates and quality of the gel coat finish. Testing demonstrated that emission reductions from the use of nonatomizing spray equipment were not technically feasible. When operated at pressures necessary to obtain UEF factors in the rule, the product was inferior. When operated at pressures under which the product specifications could be met, no emission reductions are obtainable. Based on the testing results, staff is proposing to delete the requirement of application gel coats solely with nonatomizing spray application techniques.

The AQMD had previously estimated that the use of the nonatomizing application equipment would reduce VOC emissions from gel coats sprayed by Rule 1162 operations by approximately 0.43 ton per day. Therefore, this amendment will result in foregone VOC emissions reductions of 0.43 tons per day.

## **BACKGROUND**

Rule 1162 requires open molding composite fabricators in the AQMD to use nonatomizing spray application technique in applying resins and gel coats by July 1, 2002 and July 1, 2005, respectively. The emissions reduction of the nonatomizing spray application technique was

documented in several studies, in particular, the Composite Manufacturers Association (CFA) and Clean Manufacturing Technology and Safe Materials Institute (CMTI) testing program. The CFA/CMTI studies include resins and gel coats atomizing and nonatomizing applications. The CFA emission rates were measured as pounds of VOC per ton of sprayed gel coats or resins. The results were published UEF table (2001). UEF rates estimate the VOC emission reduction of the nonatomizing spray application technique of gel coats to be approximately 40% by weight as compared to the atomized applications.

Rule 1162 (b) (19) defines the nonatomizing spray application technique as “any application technique in which resin or gel coat flows from the applicator, in a steady and observable coherent flow, without droplets, for a minimum distance of three (3) inches from the applicator orifices”.

During the implementation of Rule 1162, gel coat nonatomizing spray applications encountered difficulties in achieving the required three (3) inches coherent flow, as specified in the definition. Staff also confirmed the same difficulties during Rule 1162 Technical Assessment study (January 2003) that addressed the feasibility of gel coat nonatomizing application.

On July 11, 2003, the AQMD Governing Board amended the effective date for nonatomizing spray application for gel coats in Rule 1162 from July 1, 2003, to July 1, 2004, to allow for more testing of the gel coat nonatomizing spray application technique. The Gel Coat Testing Program was scheduled to be completed in March 2004. However, on February 12, 2004, the spray equipment manufacturers unexpectedly withdrew from the program and the testing was suspended.

On July 9, 2004, the AQMD Governing Board amended the effective date for the gel coat nonatomizing spray application requirement in Rule 1162 from July 1, 2004, to July 1, 2005, to allow for additional time to implement the Gel Coat Testing Program and develop an appropriate definition of the nonatomizing spray application technique of gel coat. At that time, an additional requirement was added that the nonatomizing spray application equipment be operated under conditions that ensure ACMA recommended UEF factors be obtained.

Throughout 2004, staff in cooperation with the ACMA, spray equipment manufacturers, gel coat manufacturers and major composite fabricators developed and conducted the Gel Coat Testing Program from August through October 2004. These tests conclude that it is infeasible to meet the rule requirements with the technology specified. Staff does not have any indication that technology is developed that will enable emission reductions anticipated for the rule can be obtained. The entire test report will be included in the Draft Staff Report.

## **AFFECTED SOURCES**

Proposed Amended Rule 1162 applies to all composite operations in the AQMD, which include but are not limited to, the manufacturers of the following:

- Bathtub, shower and vanity installations;
- Hulls for recreational and commercial watercraft;
- Bodies for recreational vehicles;
- Building panels and appliances;

- Sporting equipment and power tools;
- Automotive, aerospace and aircraft components; and
- Structural components for chemical process equipment and storage tanks.

Based on the 1998-99 AQMD Emissions Inventory, staff has identified 81 composite facilities in the AQMD subject to Rule 1162. The annual emissions inventory of these facilities, based on the UEF (1999), is estimated to be 7.98 tons per day of VOC. Additionally, the 1998-99 Emissions Inventory indicates that 24 of the composite facilities in the AQMD emit greater than 20 tons of VOC per year and utilize spray booth(s) in their operations. These 24 facilities represent approximately 78% of the total VOC emissions from composite operations in the AQMD.

## **PROPOSED AMENDMENT**

PAR 1162 includes the following amendments:

- ✓ Add paragraphs (b)(1), (b)(4) and (b)(15), the definition of the air-assisted airless spray, electrostatic application and high-volume, low-pressure spray, respectively. These techniques and other similar application techniques that result in equivalent emission reductions are required to apply gel coat to an open mold surface.
- ✓ Delete paragraph (b)(20), the definition of nonatomizing spray application technique of gel coat. This technique is allowed but no longer required to apply gel coat materials to an open mold surface,
- ✓ Modify subparagraph (c)(1)(B) to delete the requirement of gel coat nonatomizing spray application technique, and the modified version of the U.S. EPA definition for nonatomizing application technique for gel coats as found in the National Emission Standard for Hazardous Air Pollutants (NESHAP) for Reinforced Plastic Composites Production (40CFR63 Subpart WWWW) and add the requirement to apply gel coats using any applicable nonatomizing applications techniques listed in subparagraph (c)(1)(A), air-assisted airless spray, electrostatic application or high-volume, low pressure spray application techniques.
- ✓ Modify paragraph (c)(4) to read "...hand-held spray gun which has a container for resin or gel coat ..." The amendment clarifies that a hand-held spray gun can also be used for gel coat touch-up and repair since such processes can not be performed using a paint brush application.

## **CONTROL TECHNOLOGY**

Generally for coatings, nonatomizing spray application technique reduces VOC emission by applying the sprayed materials at significantly lower spray gun operation pressures with relatively larger droplets, minimizing significantly the droplets number and their surface area, as compared to the atomized application. The nonatomizing application technologies include, nonatomizing spray application technologies, flow coaters, pressure-fed rollers, resin impregnators and hand lay-up.

Several recent studies were conducted to evaluate the control efficiency of the nonatomizing application technologies. CFA/CMTI studies represent the most comprehensive evaluation of the emission rates of gel coats and resins applications. These studies were conducted at the Coating Applications Research Institute (CARL), CMTI, Purdue University. These studies indicated that the use of the nonatomizing spray application technique to apply gel coats at certain operating pressures achieves an average VOC emissions reduction of about 40% by weight. The emission rates of different applications of resins and gel coats were published in the UEF tables (1999 & 2001).

In 2004, the AQMD conducted the Gel Coat Testing Program. The objective of the testing program was to determine the minimum range of pressure values at the tip of the nonatomizing spray gun that produces gel coat sprayed products with surface quality that is no less than the surface quality achieved when using an atomizing spray gun in accordance with the composite industry standards and achieves the emissions rates stated in the UEF table (2001) for composite manufacturers operating in the AQMD.

The program measured VOC emission rates, pressure at the tip of the spray gun and surface quality using air-assisted airless and nonatomizing spray application equipment. Testing was conducted under various operating pressures the spray equipment manufacturers believed was necessary to achieve the surface quality required by the composite industry. The gel coats sprayed included clear, san bright white, midnight blue and sandable gray gel coats. The monomer content of the gel coats sprayed, and the VOC emission rates of the air-assisted airless and nonatomizing application equipment are listed in Table 1.

**Table 1**  
**VOC Emission Rates Comparing Unified Emission Factors (UEF) and AQMD Testing Program for Gel Coat Air-Assisted Airless and Nonatomized Applications**

Gel Coat	Monomer Content %	VOC Emissions lb/Ton (Pounds of VOC per Ton of Sprayed Gel Coat)			
		Atomized Application		Nonatomized Application	
		UEF	AQMD	UEF	AQMD
Clear	40.9	460	438	268	457
San Bright White	30.8	274	373	177	306
Midnight Blue	32.9	293	233	196	209
Sandable Gray	27.3	243	223	145	207

The AQMD Gel Coat Testing Program also included the collection and analysis of cured spray gel coat film samples. The samples were sent to California Polytechnic State University, San Luis Obispo for analysis. Surface quality analysis included porosity and water resistance tests (using ANSI Z124), orange peel test (using Distinctness of Image (DOI) orange peel panels), and Gloss (using ASTM D523). Surface quality analysis showed no significant differences between the air-assisted airless and nonatomizing applications (for more detailed information, please see Attachment A).

The data collected through the Gel Coat Testing Program demonstrates that it was technologically infeasible to apply gel coat materials with nonatomizing spray application equipment at pressures needed to achieve the UEF emission factors at the industry surface quality requirements.

## **EMISSIONS INVENTORY AND EMISSIONS FOREGONE**

Prior to November 17, 2001 Rule 1162 amendment, composite fabricators applied gel coats using atomized spray applications such as air-assisted airless and high-volume, low pressure spray application equipment. The Rule 1162 amendment in 2001 required fabricators to use the nonatomizing spray application technique for gel coats and resins. The VOC emissions reduction associated with the nonatomizing spray application technique of gel coats was calculated based on the difference between the emission rates for the atomized and nonatomized spray application equipment listed in the UEF table (2001).

Current PAR 1162 deletes the requirement of nonatomizing application of gel coats. Therefore, the VOC emissions reduction associated with the nonatomizing spray application of gel coats (as part of November 17, 2001 Rule 1162 amendment) are now VOC emissions foregone.

### **Emissions Inventory of the Nonatomizing Spray Application of Gel Coats**

The emissions inventory/foregone associated with the nonatomizing spray application of gel coats are calculated based on the following:

- The emissions inventory of gel coats is based on the 1998-99 emissions inventory of composite operations in the AQMD. That inventory reflects a usage of 2,206.1 tons per year of gel coats.
- The emissions inventory of gel coats includes clear and pigmented gel coats. Clear gel coats include marble clear gel coats and other clear gel coats. Pigmented gel coats include white and off-white gel coats and non- white gel coats.
- The emissions inventory of gel coats is based on compliance with the July 1, 2003, monomer content requirements for gel coats as follows: marble clear gel coats (40%), other clear gel coats (44%), white and off-white gel coats (30%), and nonwhite gel coats (37%). It also based on the atomized application of gel coats.
- Clear and pigmented gel coats represent 15% and 85%, respectively, of the total gel coats usage in composite operations in the AQMD during 1998-99.



- White /off-white, and non-white represent 85% and 15%, respectively, of the total pigmented gel coats usage in composite operations in the AQMD during 1998-99.
- Marble clear gel coats and other clear gel coats represent 35%, and 65%, respectively, of the total clear gel coats usage in the AQMD during 1998-99.
- The emissions reduction of the nonatomizing application for marble clear gel coats, other clear gel coats, white and off-white pigmented gel coats, and non-white pigmented gel coats are calculated using the 2001 UEF (see Attachment B).
- The nonatomizing emissions reduction of gel coats is calculated using the gel coat emissions inventory and the emissions reduction efficiency for the nonatomizing application of gel coats.

(1) Emissions Inventory From Gel Coats

Table 2 lists the VOC emissions from gel coats based on the current Rule 1162 monomer content, and subcategories of gel coat materials after July 1, 2003, without the use of nonatomizing application technologies.

**Table 2**  
**VOC Emissions Inventory of Gel Coats Based on July 1, 2003**  
**Monomer Content and without Nonatomizing Applications**

Specific Type of Gel Coat, & Sub-Category	Allowed Monomer Percentage in Current Rule after July 1, 2003 (%)	Unified Emission Factor <sup>a</sup> (in pounds of styrene per tons of gel coat)	Units Adjustment Factor (1 ton = 2000 pounds)	Estimated Annual Total Gel Coat Usage (in tons per year)	Percentage of Estimated Annual Total Gel Coat Usage per Type & Sub-Category	Projected VOC Emissions From Gel Coats (in tons per year)
Clear, for marble resins	40	(439	÷ 2000)	x 2206.10	x 0.15 x 0.35	= 25.42
Clear, for other resins	44	(522	÷ 2000)	x 2206.10	x 0.15 x 0.65	= 56.14
Pigmented, White and Off White	30	(267	÷ 2000)	x 2206.10	x 0.85 x 0.85	= 212.79
Pigmented, Non-White	37	(377	÷ 2000)	x 2206.10	x 0.85 x 0.15	= 53.02
a) UEFs for Open Molding of Composites, July 23, 2001 (see Attachment)					<b>TOTAL</b>	<b>347.37</b>

(2) Efficiency of Nonatomizing Application of Gel Coats

The efficiency of gel coats nonatomizing applications are calculated using the ( $E_{\text{atm}}$ ) the emissions of atomizing application and the ( $E_{\text{non.}}$ ), emissions of nonatomizing application, for each gel coat as follows:

$$\text{Efficiency of Nonatomizing Application} = (E_{\text{atm.}} - E_{\text{non.}} / E_{\text{atm.}}) \times 100$$

- (A) Clear Gel Coats:
- (I) *Marble Resins (40% monomer content)*  
 $(439-259/439) \times 100 = 41\%$
- (II) *Other Resins (44% monomer content)*  
 $(522-296/522) \times 100 = 43.30\%$
- (B) Pigmented Gel Coats:
- (I) *White and Off-white (30% monomer content)*  
 $(267-169.36/267) \times 100 = 36.57\%$
- (II) *Non-white (37 % monomer content)*  
 $(377-232/377) \times 100 = 38.46\%$

The emissions reductions of the nonatomizing application of gel coats are calculated using the emissions inventory and nonatomizing application efficiency of each gel coat. Table 3 illustrates the emissions inventory and reduction of gel coats.

**Table 3**  
**VOC Emissions Inventory and Emission Reductions from Gel Coats**

Gel Coat /Monomer Content	Atomizing Emissions Inventory (tpy)	% of Nonatomizing application Efficiency	Nonatomizing Emission Reductions (tpy)
Marble Gel Coats/40%	25.42	41.00	10.42
Other Gel Coats/44%	56.14	43.30	24.31
White and Off-White Gel Coats/30%	212.79	36.57	77.82
Non-White Gel Coats/37%	53.02	38.46	20.39
<b>Total</b>	<b>347.37</b>		<b>132.94</b>

The VOC emissions reduction associated with gel coats nonatomizing spray application technique is estimated for gel coats is 132.94 tpy or 0.43 tpd. (Rule 1162 Staff Report, 2004). Therefore, the VOC emissions foregone resulting from the amendment is 0.43 tpd.

## **COST IMPACTS**

There will be no cost impacts associated with the proposed amendment because the existing equipment can be used by the industry.

## **ENVIRONMENTAL ASSESSMENT**

Pursuant to the California Environmental Quality Act (CEQA) and the AQMD's Certified Regulatory Program (Rule 110), the AQMD is preparing a draft Subsequent Environmental Assessment (SEA) for Proposed Amended Rule 1162 – Polyester Resin Operations. In

accordance with CEQA Guidelines §15162 (a)(1), a Draft SEA will be prepared because the proposed project creates new significant adverse environmental impacts. The draft SEA will be released for a 45-day public review period. Comments received during the review period will be responded to and included in the Final SEA. Copies of the draft SEA can be obtained by calling the AQMD's Public Information Center at (909) 396-3600, upon its release.

## **SOCIOECONOMIC ANALYSIS**

The proposed amendment to Rule 1162 would delete the requirement of the nonatomizing spray application of gel coats, which would not result in additional costs to the affected sources because the existing equipment can be used by the industry. There, no socioeconomic impact analysis has been prepared.

## **COMPARATIVE ANALYSIS**

As required by Health and Safety Code Section 40727.2, the purpose of this analysis is to identify and analyze any federal or other AQMD rules that apply to the same equipment or source type as the proposed amendments. In addition to PAR 1162, the composite operations in the AQMD are also subject to Rule 1132 and the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reinforced Plastic Composites Production (40CFR63, Subpart WWW) and for Boat Manufacturing (40 CFR Part 63, Subpart VVVV). A comparative analysis of these requirements with the proposed amendments is summarized in Table 4.

## **CONCLUSIONS AND RECOMMENDATIONS**

Staff has determined that there are no significant differences between the VOC emission rates of the air-assisted airless and nonatomizing applications. Therefore, it is staff's recommendation that Rule 1162 be amended to delete the requirement of the nonatomizing spray application technique of gel coat. In addition, staff proposes to add language to clarify that a hand-held spray gun can be used for touch-up and repair for gel coat and resin applications.

## **DRAFT FINDINGS**

Before adopting, amending or repealing a rule, the AQMD shall make findings of necessity, authority, clarity, consistency, non-duplication, and reference, as defined in Health and Safety Code Section 40727. The draft findings are as follows:

**Authority** - The AQMD Governing Board obtains its authority to adopt, amend or repeal rules and regulations from Health and Safety Code §§40000, 40001, and 40440.

**Clarity** - The AQMD Governing Board finds and determines that Proposed Amended Rule 1162 is written and displayed so that the meaning can be easily understood by persons directly affected by it.

**Consistency** – The AQMD Governing Board finds and determines that Proposed Amended Rule 1162 is in harmony with, and not in conflict with or contradictory to, existing statutes, court decisions, or federal or state regulations.

**Non-Duplication** – The AQMD Governing Board has determined that Proposed Amended Rule 1162 does not impose the same requirements as any existing state or federal regulation, and the extent they overlap with NESHAP requirements are necessary to carry out the duty to adopt rules implementing the AQMP.

**Reference** - In adopting these proposed amendments, the AQMD Governing Board references the following statutes which AQMD hereby implements, interprets or makes specific: Health and Safety Code Sections 40001 and 40440.

## **REFERENCES**

South Coast Air Quality Management District, “Draft Final AQMD Gel Coat Testing Program Report” February 2005.

South Coast Air Quality Management District, “Final Staff Report For Proposed Amended Rule 1162-Polyester Resin Operations,” July 9, 2004.

South Coast Air Quality Management District, “Final Staff Report For Proposed Amended Rule 1162-Polyester Resin Operations,” July 11, 2003.

South Coast Air Quality Management District, “Final Staff Report For Proposed Amended Rule 1162-Polyester Resin Operations,” November 9, 2001.

R.A. Haberlein, “Technical Discussion of the United Emission Factors for Open Molding Composite,” Engineering Environmental, July 17, 2001.

**Table 4**  
**Comparison Analysis of PAR 1162, Rule 1132 and 40 CFR Part 63 Subparts VVVV and WWWW Requirements**

PAR 1162	RULE 1132	40 CFR PART 63 Subpart VVVV	40 CFR PART 63 Subpart WWWW
<u>Objective</u> Controls VOC and HAP emissions.	Further controls of VOC and HAP emissions beyond Rule 1162.	Controls HAP emissions.	Controls HAP emissions.
<u>Applicability</u> Applies to all composite operations.	Applies to composite facilities, which emit > 20 tpy of VOCs and utilize paint spray booth(s) in their operations.	Applies to boat manufacturing composite facilities, which represent major source of HAPs.	Applies to the production of reinforced and non-reinforced plastic composite, as well as intermediate compounds.
<u>Compliance Options</u> -Pollution Prevention Technologies -Add-on Control	-Pollution Prevention Technologies -Add-on control -Combination between Pollution Prevention Technologies and Add-on Controls.	-Compliant materials -Add-on Control -Point Value Averaging	-HAP limits listed in Table 1 for sources < 100 tpy - 95 % control required for sources ≤100 tpy -Allows average weighted HAP emissions limits.
<u>Compliance Effective Dates</u> -July 1, 2002: Nonatomizing applications of resins and lower monomer content of gel coats  July 1, 2003: Lower monomer content of gel coats and resins	-January 1, 2002: Nonatomizing application of resins (gel coats excluded) and lower monomer contents of gel coats.  -July 1, 2004: Reduction of VOC emissions by 65 % of Rule 1162 limits in effect as of January 19, 2001.	-August 22, 2001: New facilities must comply with the regulation requirements.  -August 22, 2004: Existing facilities must comply with the regulation requirements	- April 21, 2006: Existing major source - April 21, 2003: New major source (constructed after August 2, 2001) - Upon Start Up: New major source (constructed after April 21, 2003) - After three year of the change: Existing area source become a major source - Upon the change: New area source become a major source
<u>Equipment Requirement</u> Requires nonatomizing technologies for resin applications.	Requires nonatomizing application technologies only for resins.	Allows atomizing and nonatomizing applications.	Allows atomizing and nonatomizing applications.

**Table 4**  
**Comparison Analysis of PAR 1162, Rule 1132 and 40 CFR Part 63 Subparts VVVV and WWWW Requirements**  
**(Cont'd)**

PAR 1162	RULE 1132	40 CFR PART 63 Subpart VVVV	40 CFR PART 63 Subpart WWWW
<u>Monomer Content by weight</u>			
Clear Gel Coat	44 % (VOC)	48 % (MHC)*	44 % (MHC)*
-For Marble Resin 40 % (VOC)	N/A	N/A	N/A
-Other resins 44 % “	N/A	N/A	N/A
Pigmented Gel Coats			30%
-White and off-white 30 % “	30 % “	33 % “	37%
-Non-white 37 % “	37 % “	40 % “	30%
General Purpose Resins	35 % “	35 % “	N/A
-Marble Resins 10 % “	N/A	N/A	N/A
-Tub/Shower Resin 20 % “	N/A	N/A	N/A
-Lamination Resins 35 % “	N/A	N/A	N/A
-Others 35 % “	N/A	N/A	N/A
Specialty Resins			>50%
-Fire Retardant 38 % “	42 % “	N/A	33%
-Corrosion Resist. 48 % “	48 % “	39 % “	33%
-High Strength 40 % “	48 % “	N/A	
		(MHC)*: Maximum HAP Content	(MHC)*: Maximum HAP Content
<u>Fillers</u>			
Offers fillers as an option to comply with the monomer content requirement of the applicable resins.	N/A	N/A	N/A
<u>Vapor Suppressants</u>			
Requires that tub/shower resins to be vapor suppressed.	N/A	N/A	Table 3 includes equations to calculate the emission rates of vapor suppressed resins
<u>Closed Molding System</u>			
Requires < 4 % weight loss of polyester resins during polymerization	N/A	N/A	N/A
<u>Pultrusion Operation</u>			
Requires < 3 % weight loss of polyester resins during polymerization	N/A	N/A	Reduce total HAP emissions by at least 60% by weight

**Attachment A**  
**Unified Emission Factors**



# Unified Emission Factors for Open Molding of Composites

July 23, 2001

## Emission Rate in Pounds of Styrene Emitted per Ton of Resin or Gelcoat Processed

Styrene content in resin/gelcoat, % <sup>(1)</sup>	<33 <sup>(2)</sup>	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	>50 <sup>(2)</sup>
Manual	0.126 x %styrene x 2000	83	89	94	100	106	112	117	123	129	134	140	146	152	157	163	169	174	180	((0.286 x %styrene) - 0.0529) x 2000
Manual w/ Vapor Suppressed Resin VSR <sup>(3)</sup>	Manual emission factor [listed above] x (1 - (0.50 x specific VSR reduction factor for each resin/suppressant formulation))																			
Mechanical Atomized	0.169 x %styrene x 2000	111	126	140	154	168	183	197	211	225	240	254	268	283	297	311	325	340	354	((0.714 x %styrene) - 0.18) x 2000
Mechanical Atomized with VSR <sup>(5)</sup>	Mechanical Atomized emission factor [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
Mechanical Atomized Controlled Spray <sup>(4)</sup>	0.130 x %styrene x 2000	86	97	108	119	130	141	152	163	174	185	196	207	218	229	240	251	262	273	0.77 x ((0.714 x %styrene) - 0.18) x 2000
Mechanical Controlled Spray with VSR	Mechanical Atomized Controlled Spray emission factor [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
Mechanical Non-Atomized	0.107 x %styrene x 2000	71	74	77	80	83	86	89	93	96	99	102	105	108	111	115	118	121	124	((0.157 x %styrene) - 0.0165) x 2000
Mechanical Non-Atomized with VSR <sup>(3)</sup>	Mechanical Non-Atomized emission factor [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
Filament application	0.184 x %styrene x 2000	122	127	133	138	144	149	155	160	166	171	177	182	188	193	199	204	210	215	((0.2746 x %styrene) - 0.0298) x 2000
Filament application with VSR <sup>(5)</sup>	0.120 x %styrene x 2000	79	83	86	90	93	97	100	104	108	111	115	118	122	125	129	133	136	140	0.65 x ((0.2746 x %styrene) - 0.0298) x 2000
Gelcoat Application	0.445 x %styrene x 2000	294	315	336	356	377	398	418	439	460	481	501	522	543	564	584	605	626	646	((1.03646 x %styrene) - 0.195) x 2000
Gelcoat Controlled Spray Application <sup>(4)</sup>	0.325 x %styrene x 2000	215	230	245	260	275	290	305	321	336	351	366	381	396	411	427	442	457	472	0.73 x ((1.03646 x %styrene) - 0.195) x 2000
Gelcoat Non-Atomized Application <sup>(6)</sup>	SEE Note 9 below	196	205	214	223	232	241	250	259	268	278	287	296	305	314	323	332	341	350	((0.4506 x %styrene) - 0.0505) x 2000
Covered-Cure after Roll-Out	Non-VSR process emission factor [listed above] x (0.80 for Manual <or> 0.85 for Mechanical)																			
Covered-Cure without Roll-Out	Non-VSR process emission factor [listed above] x (0.50 for Manual <or> 0.55 for Mechanical)																			

## Emission Rate in Pounds of Methyl Methacrylate Emitted per Ton of Gelcoat Processed

MMA content in gelcoat, % <sup>(6)</sup>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	≥20
Gel coat application <sup>(7)</sup>	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	0.75 x %MMA x 2000

### Notes

- Including styrene monomer content as supplied, plus any extra styrene monomer added by the molder, but before addition of other additives such as powders, fillers, glass,...etc.
- Formulas for materials with styrene content < 33% are based on the emission rate at 33% (constant emission factor expressed as percent of available styrene), and for styrene content > 50% on the emission rate based on the extrapolated factor equations; these are not based on test data but are believed to be conservative estimates. The value for "% styrene" in the formulas should be input as a fraction. For example, use the input value 0.30 for a resin with 30% styrene content by wt.
- The VSR reduction factor is determined by testing each resin/suppressant formulation according to the procedures detailed in the *CFA Vapor Suppressant Effectiveness Test*.
- SEE the *CFA Controlled Spray Handbook* for a detailed description of the controlled spray procedures.
- The effect of vapor suppressants on emissions from filament winding operations is based on the *Dow Filament Winding Emissions Study*.
- Including MMA monomer content as supplied, plus any extra MMA monomer added by the molder, but before addition of other additives such as powders, fillers, glass,...etc.
- Based on gelcoat data from *NMMA Emission Study*.
- SEE the July 17, 2001 EECS report *Emission Factors for Non-Atomized Application of Gel Coats used in the Open Molding of Composites* for a detailed description of the non-atomized gelcoat testing.
- Use the equation: ((0.4506 x %styrene) - 0.0505) x 2000 for gelcoats with styrene contents between 19% and 32% by wt.; use the equation 0.185 x %styrene x 2000 for gelcoats with less than 19% styrene content by wt.